ROS Localization

Wego & Industrial Robot

WeGo

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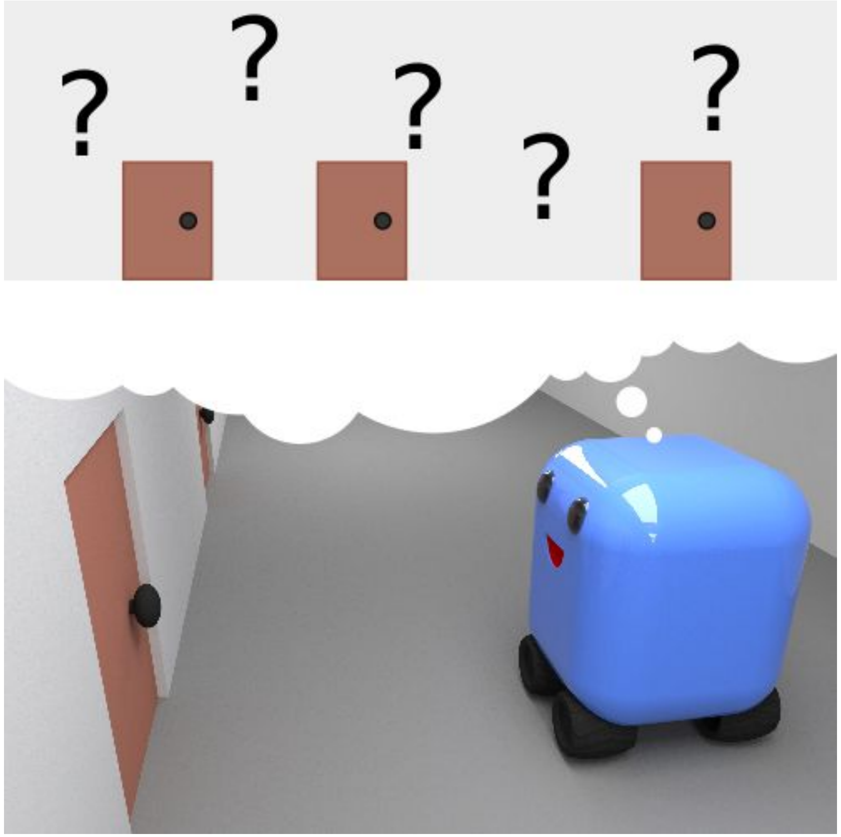
01

Introdunction to

Localization

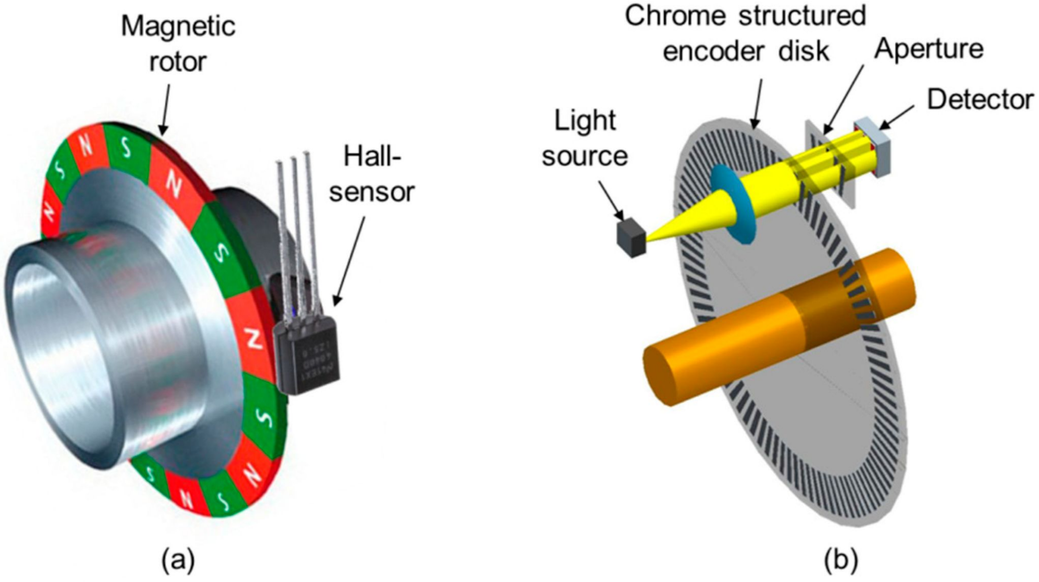
01 Introduction to Localization

- Navigation은 Mobile Robot 관점에서 핵심적인 기능 중 하나입니다.
- Navigation을 위해서는 로봇의 현재 위치를 파악하는 것이 중요합니다.
- 주어진 지도 상에서 로봇의 현재 위치를 파악하는 기술을 Localization(지역화) 기술이라고 합니다. 또는 위치 추정(Position Estimation)이라고도 합니다.



01 Introduction to Localization

- 로봇의 형태 및 자유도에 따라서 추정해야하는 차원 수가 달라집니다.
- 일반적인 2D 환경에서 이동하는 Mobile Robot의 경우는 지도 상에서의 위치(x, y) 및 헤딩 각(θ)의 세 가지 정보를 Pose $x_t = (x, y, \theta)^T$ 다음과 같이 표시한다.
- 사용하는 센서로는 내부의 이동을 측정하는 Odometer (주행 기록계) 및 LiDAR 센서 데이터 두 가지를 사용한다.



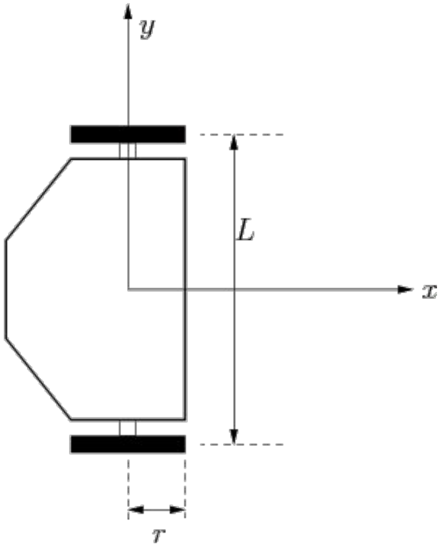
01 Introduction to Localization

- Differential Drive Model

$$\dot{x} = \frac{r}{2}(v_l + v_r)cos(\theta)$$
$$\dot{y} = \frac{r}{2}(v_l + v_r)sin(\theta)$$
$$\dot{\theta} = \frac{r}{L}(v_r - v_l)$$

$$\dot{x} = vcos(\phi)$$
$$\dot{y} = vsin(\phi)$$
$$\dot{\phi} = \omega$$

(a)



(b)

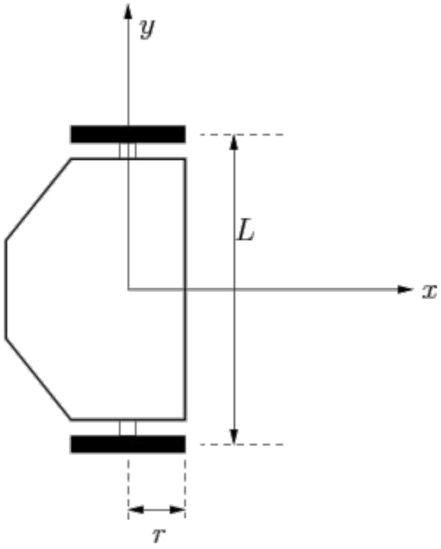
01 Introduction to Localization

- Differential Drive Model

$$v = \frac{R}{2}(v_r + v_l)$$

$$\omega = \frac{R}{L}(v_r - v_l)$$

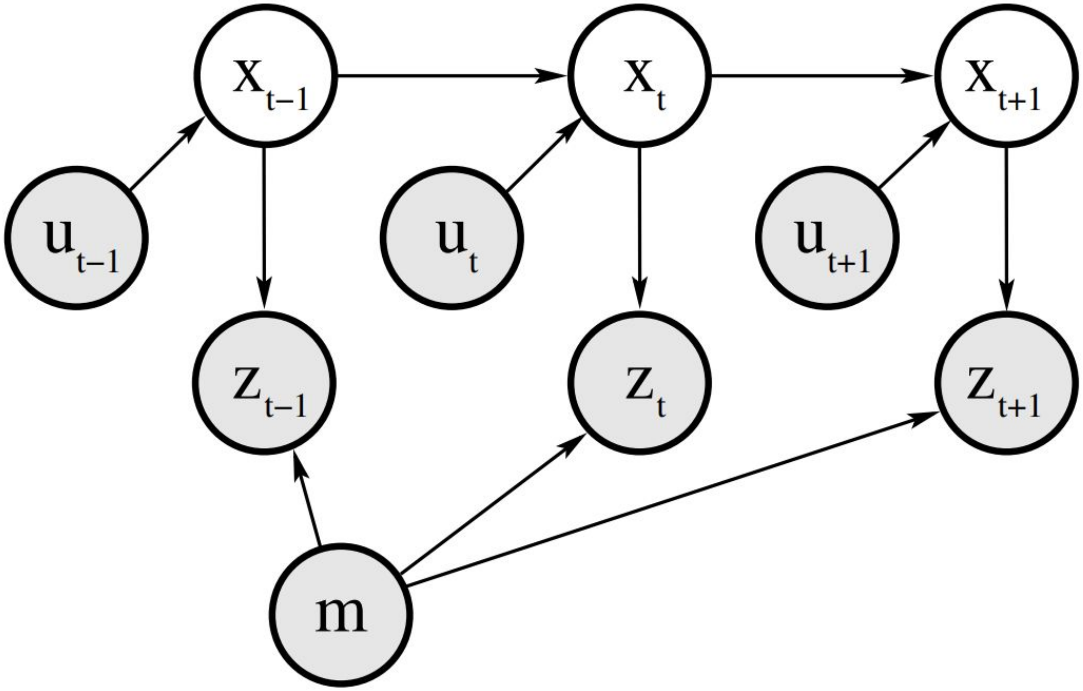
(a)



(b)

01 Introduction to Localization

- Mobile Robot Localization Graphical Model
  - ○ Robot State x_{t-1}
  - ○ Map Data m
  - ○ Measurement (LiDAR) z_{t-1}
  - ○ Control Data (Odometry) u_{t-1}



01 Introduction to Localization

- Position Tracking – 로봇의 초기 위치를 알고 있고, 이를 기반으로 로봇의 움직임을 추적하여, 로봇의 위치를 추정하는 방법 (Local Problem)
- Global Localization – 로봇의 초기 위치를 모르는 상태이며, 지도 상의 한 점에서 시작을 하지만 위치는 알 수 없는 상태(Global Problem)

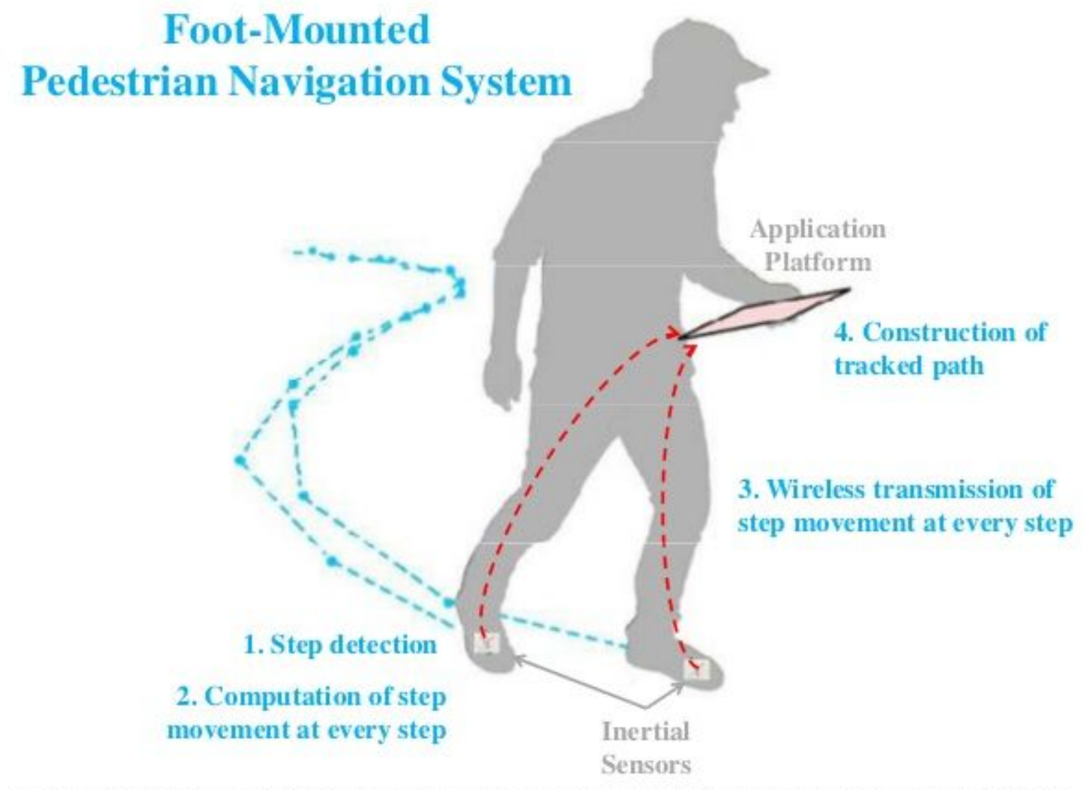
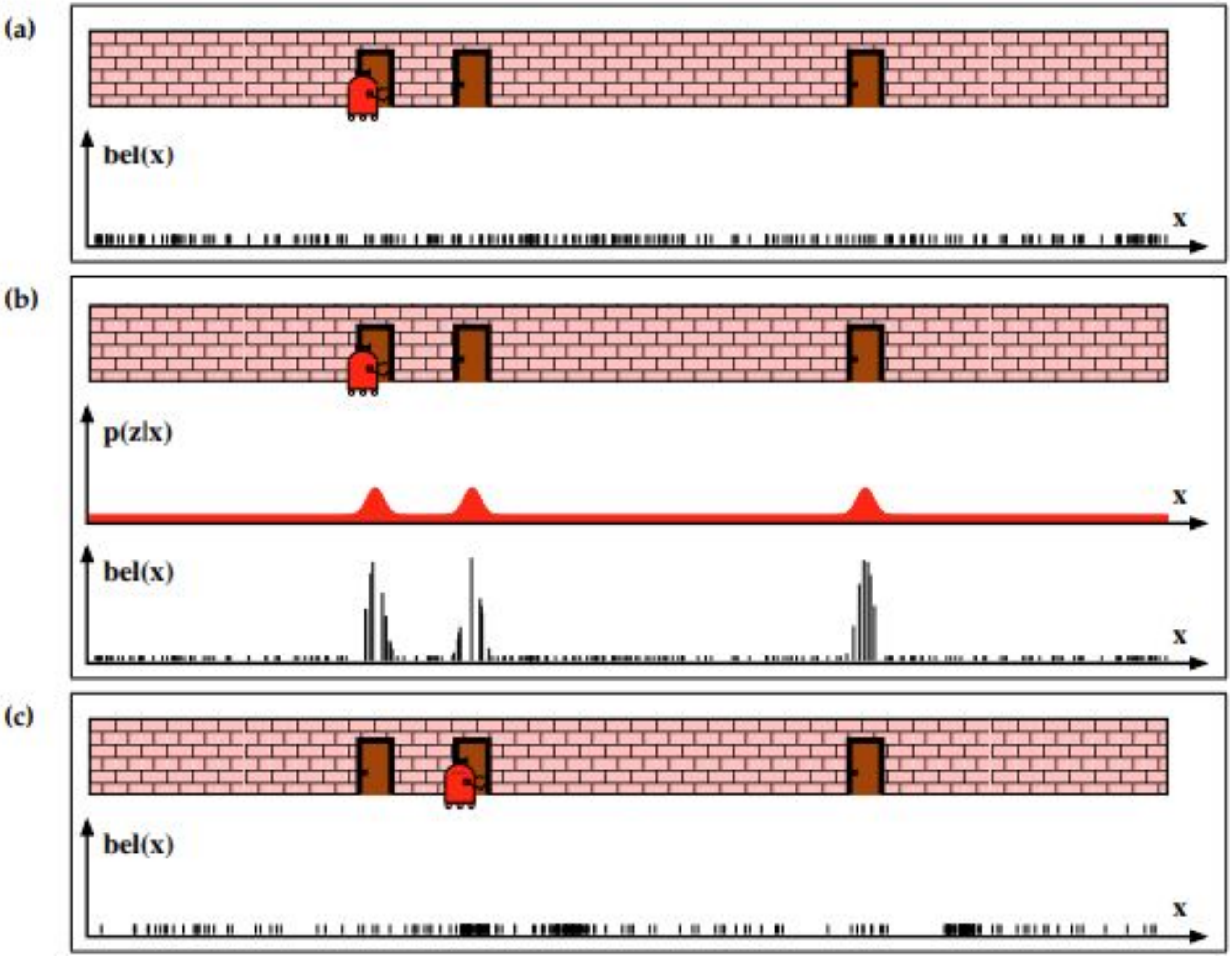


Image source: John-Olof Nilsson, Amit K Gupta, Peter Handel, "Foot mounted inertial navigation made easy", Proc Indoor Positioning & Indoor Navigation (IPIN), 2014

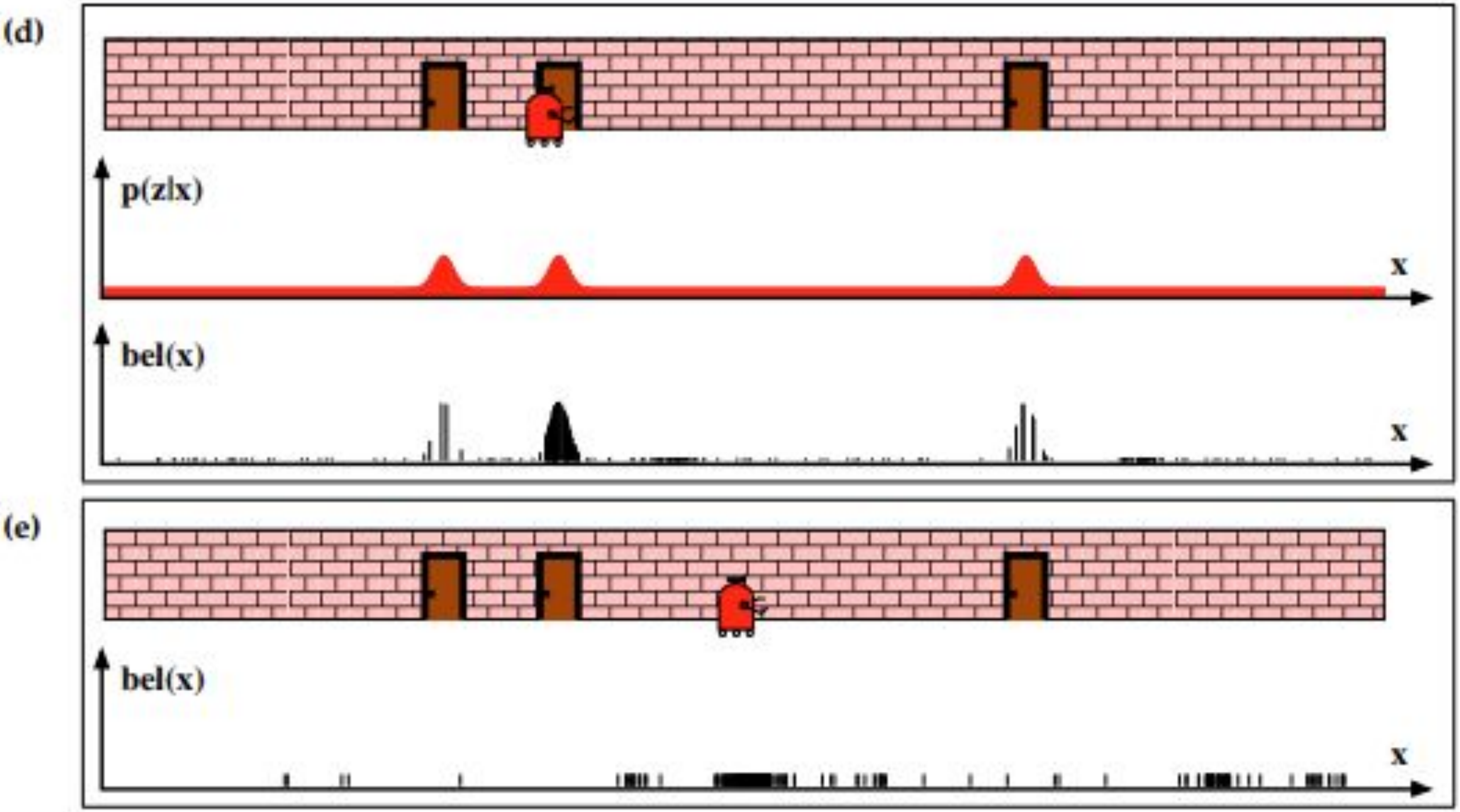
- Monte Carlo Localization(Particle Filter)

  1. 전체 지도에서 균일하게 확률 분포를 생성한다.
  2. 로봇의 센서를 통해 주변 환경을 확인하고 확률 분포를 업데이트한다.
  3. 로봇을 이동시키고, 로봇의 이동한 값을 이용하여 확률 분포를 업데이트한다.
  4. 2 ~ 3의 과정을 반복하여 수렴시킨다.

01 Introduction to Localization



01 Introduction to Localization



02

Localization Package

ROS AMCL package

- **amcl - adaptive monte carlo localization**
- **Published Topics**
  - amcl_pose (geometry_msgs/PoseWithCovarianceStamped) - Robot's estimated pose in the map, with covariance.
  - particlecloud (geometry_msgs/PoseArray) - The set of pose estimates being maintained by the filter.
  - tf (tf/tfMessage) - Publishes the transform from odom (~odom_frame_id parameter) to map.
- **Subscribed Topics**
  - scan (sensor_msgs/LaserScan) - Lidar Laser scan data.
  - tf (tf/tfMessage) - Transforms.
  - initialpose (geometry_msgs/PoseWithCovarianceStamped) - Mean and covariance with which to (re-)initialize the PF.
  - map (nav_msgs/OccupancyGrid) - When the use_map_topic parameter is set, AMCL subscribes to map topic to retrieve the map used for laser-based localization

ROS AMCL package

- **amcl - adaptive monte carlo localization**
- **Parameters(Default) -** Overall filter parameters
  - ~min_particles (100) - Minimum allowed number of particles.
  - ~max_particles (5000) - Maximum allowed number of particles.
  - ~kld_err (0.01) - Maximum error between the true distribution and the estimated distribution.
  - ~kld_z (0.99) - Upper standard normal quantile for (1 - p), where p is the probability that the error on the estimated distrubition will be less than kld_err.
  - ~update_min_d (0.2 meters) - Translational movement required before performing a filter update.
  - ~update_min_a (π/6.0 radians) - Rotational movement required before performing a filter update.
  - ~resample_interval (2) - Number of filter updates required before resampling.
  - ~transform_tolerance (0.1 seconds) - Time with which to post-date the transform that is published, to indicate that this transform is valid into the future.
  - ~recovery_alpha_slow (0.0 (disabled)) - Exponential decay rate for the slow average weight filter, used in deciding when to recover by adding random poses. A good value might be 0.001.
  - ~recovery_alpha_fast (0.0 (disabled)) - Exponential decay rate for the fast average weight filter, used in deciding when to recover by adding random poses. A good value might be 0.1.
  - ~initial_pose_x (0.0 meters) - Initial pose mean (x), used to initialize filter with Gaussian distribution.
  - ~initial_pose_y (0.0 meters) - Initial pose mean (y), used to initialize filter with Gaussian distribution.
  - ~initial_pose_a (0.0 radians) - Initial pose mean (yaw), used to initialize filter with Gaussian distribution.

ROS AMCL package

- **amcl - adaptive monte carlo localization**
- **Parameters(Default) -** Overall filter parameters
  - ~initial_cov_xx (0.5*0.5 meters) - Initial pose covariance (x*x), used to initialize filter with Gaussian distribution.
  - ~initial_cov_yy (0.5*0.5 meters) - Initial pose covariance (y*y), used to initialize filter with Gaussian distribution.
  - ~initial_cov_aa ((π/12)*(π/12) radian) - Initial pose covariance (yaw*yaw), used to initialize filter with Gaussian distribution.
  - ~gui_publish_rate (double, default: -1.0 Hz) - Maximum rate (Hz) at which scans and paths are published for visualization, -1.0 to disable.
  - ~save_pose_rate (double, default: 0.5 Hz) - Maximum rate (Hz) at which to store the last estimated pose and covariance to the parameter server, in the variables ~initial_pose_* and ~initial_cov_*. This saved pose will be used on subsequent runs to initialize the filter. -1.0 to disable.
  - ~use_map_topic (bool, default: false) - When set to true, AMCL will subscribe to the map topic rather than making a service call to receive its map. **New in navigation 1.4.2**
  - ~first_map_only (bool, default: false) - When set to true, AMCL will only use the first map it subscribes to, rather than updating each time a new one is received. **New in navigation 1.4.2**
  - ~selective_resampling (bool, default: false) - When set to true, will reduce the resampling rate when not needed and help avoid particle deprivation. The resampling will only happen if the effective number of particles (*N_eff = 1/(sum(k_i^2))*) is lower than half the current number of particles. Reference: *Grisetti, Giorgio, Cyrill Stachniss, and Wolfram Burgard. "Improved techniques for grid mapping with rao-blackwellized particle filters." IEEE transactions on Robotics 23.1 (2007): 34*

ROS AMCL package

- **amcl - adaptive monte carlo localization**
- **Parameters(Default) -** Laser model parameters
  - ~laser_min_range (-1.0) - Minimum scan range to be considered, -1.0 will cause the laser's reported minimum range to be used.
  - ~laser_max_range (-1.0) - Maximum scan range to be considered; -1.0 will cause the laser's reported maximum range to be used.
  - ~laser_max_beams (30) - How many evenly-spaced beams in each scan to be used when updating the filter.
  - ~laser_z_hit (0.95) - Mixture weight for the z_hit part of the model.
  - ~laser_z_short (0.1) - Mixture weight for the z_short part of the model.
  - ~laser_z_max (0.05) - Mixture weight for the z_max part of the model.
  - ~laser_z_rand (0.05) - Mixture weight for the z_rand part of the model.
  - ~laser_sigma_hit (0.2 meters) - Standard deviation for Gaussian model used in z_hit part of the model.
  - ~laser_lambda_short (0.1) - Exponential decay parameter for z_short part of model.
  - ~laser_likelihood_max_dist (2.0 meters) - Maximum distance to do obstacle inflation on map, for use in likelihood_field model.
  - ~laser_model_type ("likelihood_field") - Which model to use, either beam, likelihood_field, or likelihood_field_prob (same as likelihood_field but incorporates the beamskip feature, if enabled).

ROS AMCL package

- **amcl - adaptive monte carlo localization**
- **Parameters(Default) -** Odometry model parameters
  - ~odom_model_type ("diff") - Which model to use, either "diff", "omni", "diff-corrected" or "omni-corrected".
  - ~odom_alpha1 (0.2) - Specifies the expected noise in odometry's rotation estimate from rotational component of robot's motion.
  - ~odom_alpha2 (0.2) - Specifies the expected noise in odometry's rotation estimate from translational component of robot's motion.
  - ~odom_alpha3 (0.2) - Specifies the expected noise in odometry's translation estimate from translational component of robot's motion.
  - ~odom_alpha4 (0.2) - Specifies the expected noise in odometry's translation estimate from the rotational component of robot's motion.
  - ~odom_alpha5 (0.2) - Translation-related noise parameter (only used if model is "omni").
  - ~odom_frame_id ("odom") - Which frame to use for odometry.
  - ~base_frame_id ("base_link") - Which frame to use for the robot base
  - ~global_frame_id ("map") - The name of the coordinate frame published by the localization system
  - ~tf_broadcast (true) - Set this to false to prevent amcl from publishing the transform between the global frame and the odometry frame.

- http://wiki.ros.org/amcl

Q & A

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